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(54) COMPRESSOR REFRIGERANT SYSTEMS

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This invention relates to compressor refrigerant systems employing a fluorocarbon refrigerant combined with a lubricating composition in contact with the fluorocarbon, the lubricating composition having high lubricity and being thermally and chemically stable in the presence of partially or completely fluorocarbon refrigerants.

Refrigerant systems utilizing fluorocarbon refrigerants such as dichlorodifluoromethane (R-12) and chlorodifluoromethane (R-22) require specialized lubricants. Such systems may include not only food refrigerators, but home air conditioners and heat pumps which in winter operate by extracting heat from cold outdoor air. These lubricants must be resistant to thermal and chemical decomposition at high temperatures in the presence of fluorocarbons and provide lubrication at cold start-up. For an exhaustive review of the lubrication requirements of refrigeration compressors and systems, definition of terms and review of the art, see Guide & Data Book, Systems, Am. Soc. of Heating, Refrig. & Air Condit. Engineers, Chap. 30 pp. 435-58 (1970 Ed.). The term 'fluorocarbon' generally refers to hydrocarbon compounds having fluorine and chlorine atoms substituted for a high proportion or all of the monovalent hydrogen atoms on carbon.

At low temperature, fluorocarbon refrigerants are highly soluble in the lubricating oils, and depending upon the particular fluorocarbon and the temperature, separation occurs into two phases, one of high fluorocarbon content and the other high in oil and low in fluorocarbon. During cold operation or during the cold-cycle, poor lubrication which may occur causes high cylinder and bearing wear which may be accompanied by galling and seizing. This in part is caused

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by the condensation of the refrigerant in the crank case in cold atmospheric environment so that the lubricant is diluted with refrigerant. During start-up and with reduced pressure being applied the lubricant is swelled with gaseous refrigerant as the liquid fluorocarbon boils to produce a foam making it extremely difficult to pump through the galleries and crank shaft bearings. This is aggravated when R-22 refrigerant is used because phase separation of the liquid refrigerant and lubricant occurs and a highly

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diluted oil-froth emulsion and foam of very low viscosity is delivered to the bearings and cylinder walls. After start-up, the refrigerant in the oil progressively changes to the vapor phase or boils away from the oil, and the lubrication improves to the required degree.

It is also well-known that fluorocarbon refrigerants chemically attack the lubricants and metals, particularly at high temperatures. "Coking" or carbonization in the region of and on the hot discharge valves results from the thermal decomposition of lubricating oil vapor and mist in the presence of hot compressed refrigerant. It is believed that this is caused by the more unstable organic compounds in the oil, such as the hydrocarbons containing sulfur, nitrogen and oxygen, which remain after refining and which impart lubricity to the highly refined refrigerating oils.

Accordingly the present invention consists in a compressor refrigerant system employing a fluorocarbon refrigerant combined with a lubricating composition in contact with the fluorocarbon, the lubricating composition comprising an oil having a viscosity at 100°F of from 100 to 300 SUS, and at least 1% by weight thereof of a liquid halogenated polyphenyl compound selected from halogenated biphenyls, diphenyl ethers and alkyl derivatives thereof, the halogen being at least one of chlorine and fluorine.

The present invention involves the use of a particular lubricating composition in fluorocarbon refrigerant systems in an attempt to overcome the aforesaid problems. Specifically, a lubricating composition is provided that has greatly enhanced boundary lubricating ability during cold start-up as well as increased thermal and chemical stability

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and resistance to coking in the presence of fluorocarbon refrigerants during normal operating conditions.

The lubricant composition is a highly stable hydro-fined mineral oil base stock (such as produced by high pressure hydro-genation of oil in the presence of catalysts at high temperature) or a synthetic lubricant base with the aforesaid minor proportion of an halogenated polyphenyl compound including the halogenated biphenyls and halogenated diphenyl ethers and alkyl derivatives thereof. Additionally, commercially available refrigerant system oils, which are highly refined petroleum products such as, for example, those sold as Suniso®



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30S (Sun Oil Co.) and Texas Capella® B (Texaco Inc.) brand oils, can be modified by the addition of liquid halogenated polyphenyl compounds including the chlorinated biphenyls and chlorinated diphenyl ethers and alkyl derivatives thereof.

Outstanding improvements have been realized in thermal stability of the lubricating composition by utilizing a fully hydrofined mineral oil base stock. An example of such class of oils is that group marketed by Atlantic-Richfield (Sinclair Division) as the Tufflo® series 6004, 6014 and 6024. Hydrofining is a well known process in the petroleum refining industry. Hydrofined oil base stock has been found to be extremely resistant to thermal degradation in the presence of R-12 or R-22 refrigerants at 175°C and is thus particularly well suited as the oil base of the present invention. The thermal stability of the hydrofined oils is believed to result largely from the removal of practically all of the remaining amounts of hydrocarbons containing nitrogen, sulfur and oxygen, and the unsaturated hydrocarbons usually found in commercial refrigerator compressor oils. While these fully hydrofined oils provide excellent thermal stability, they have poor lubricating qualities. It has been noted that these mineral oil base stocks do exhibit superior lubricating properties in the presence of fluorocarbon refrigerants dissolved therein, but the refrigerant is a "floating" lubricant additive. As indicated previously, as the temperature rises in the refrigerating system, the fluorocarbon is less soluble in the base oil and evaporates and thus leaves the oil which by itself is without adequate lubricity in the compressor of the system. Accordingly, those mineral base oils alone are considered unsatisfactory as lubricants for fluorocarbon



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refrigerant systems.

In practising the present invention good results have been obtained with fully hydrofined mineral oils being used which have properties and a composition similar to the Tufflo brand of oil, series 6004 and 6014. Also quite suitable for use in the invention is

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a class of synthetic lubricants which comprises polybutenes which are butylene polymers composed mostly of high molecular weight polymers of mono-olefins, such as are marketed by the American Oil Company as Syntholube® H-5.

A further example of mineral oil base stocks found to be quite desirable in producing the lubricant compositions are the refined mineral oils of the following properties and compositions, which are available as MLO-7557 (developed for the United States Government for use in jet aircraft):

TABLE I

| COMPOSITION | % |
|---|---|
| Isoparaffins | 37.6 |
| 1-Ring Naphthenes | 23.4 |
| 2-Ring Naphthenes | 17.2 |
| 3+-Ring Naphthenes | 21.8 |
| Mol. Wt. | 231 |
| Carbons/Molecule | 23.1 |
| Naphthenic Carbon, | % of total C27 |
| Methyl Carbon, | % of total C20 |
| Methylene Carbon, | % of total C53 |
| Nitrogen-, sulfur-, and oxygen-, containing hydrocarbons | 0% |

| TEMP. °F. | VISCOSITY |
|---|---|
| 550 | .56 cs. |
| 210 | 3.32 |
| 100 | 15.41 |
| 0 | 375. |
| -40 | 3800. |
| -65 | 25,900. |

Pour Point -70°F

Note: C27, C20 and C53 are used in the trade to indicate the indicated numerical percentage of the carbon atoms in the respective type of carbon compound.

Generally, some of the more important physical properties that the base lubricant should display include a visco-

sity of from about 100-300 SUS at 100°F and a pour point not greater than -25°F. (It should be noted, however, that the pour point can be increased depending upon the end application of the system as set forth below.) The sulfur content, asphaltenes, and polar compounds are preferably nil. High saturates and high isoparaffin content are desirable. The carbon type proportioning of the oil is also important and for this reason oils with a naphthenic carbon content from about 50-60% and a paraffinic carbon content from 50-40% are particularly suitable in the practice of the invention.

Furthermore, the well recognized and commercially available anti-wear additives used in premium hydraulic and automotive oils such, for example, as tricresyl phosphate ester and the family of zinc dialkyl-aryl dithiophosphates are not particularly advantageous for use in refrigerant systems, particularly where the refrigerant is a fluorocarbon. In fact, when these additives are present the lubricants are vastly inferior, with regard to thermal stability, as compared to the lubricating composition of the present invention.

Liquid halogenated aromatics suitable for use in the present invention comprise compounds with at least one benzene ring in which at least one halogen and/or one halogenated alkyl group is substituted for hydrogen. However, because of the instability of monochloromethylbenzene and its high corrosiveness to metal, this compound or in fact any compound with a monochloromethyl group is not adapted for use in the present invention. The halogenated aromatics may comprise two or more aromatic rings joined directly to each other or through a bivalent radical such as oxygen or methylene, or fused rings such as naphthalene. Two or more halogen atoms preferably chlorine or fluorine, on the aromatic ring may be present if subsequent disposal of the halogenated alkyl compound is not a problem, since



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polyhalogens are generally more thermally stable than the mono-substituted aromatics. Illustrative of these polyhalogenated aromatics are dichlorobenzene, difluorobenzene, monochloro-difluorobenzene, pentachlorodiphenyl oxide, trichlorododecyl biphenyl, 2-chlorobenzo-trifluoromethyl and polychloroterphenyl. Mixtures of two or more halogenated aromatics may be employed, for example, 10% by weight of trichlorobenzene and 90% by weight of 40% chlorinated diphenyl oxide. A minimum of about 1% of the halogenated aromatic is needed, excellent results being achieved when about 10% to 20% halogenated aromatics are utilized.

For preparing the compositions of this invention, good results have also been obtained with chlorinated biphenyls containing on the average 42% and 48% chlorine by weight, respectively, and available commercially as Aroclor® 1242 and 1248 marketed by Monsanto Co. They are colorless to yellow tinted mobile oils having a pour point around +2°F and 19.4°F (ASTM D97), respectively. They have a specific gravity of 1.380 and 1.445 and a viscosity of 80-93 SUS and 185-240 SUS at 100°F, respectively. They exhibit outstanding chemical and thermal stability in the presence of fluorocarbons, e.g. in Table II, note examples #7 and #8. In fact, their stability is on the order of 10 times (see Table II and compare the R12 values in examples #1 and #2 with #7 and #8) that of typical commercially available refrigerant compressor oils.

Examples of other halogenated aromatics suitable for use in practicing the invention include benzotrifluoride, 2-chlorobenzotrifluoride, 1,3-bis-(trifluoromethyl)-benzene, dodecylmonochlorodiphenyl oxide, monochlorodiphenyl oxide, dichlorodiphenyl oxide, trichlorobiphenyl available as MCS 1016 Aroclor®,

and mixtures of two or more. Of these other halogenated aromatics, dodecylmonochlorodiphenyl oxide has led to particularly good results.

The halogenated aromatics can be added in widely varying amounts to achieve better lubricity as well as thermal and chemical stability in the higher temperatures ranges with a minimum of about 1% being required for noticeable results. Up to about 20% is the normal upper limit of the halogenated aromatics. The addition of the halogenated aromatics in greater amounts and particularly the higher molecular weight compounds, however, raises the pour point of the composition, Thus, for some refrigerant systems an amount greater than 25% would increase the pour point so much that it would be detrimental to the operation of the system. Where the pour point is not essential, for example, where no part of the system experiences a temperature substantially below ambient, amounts of the halogenated aromatics up to and exceeding 50% are useful. Accordingly, the proportional limitation of the composition is directly related to the pour point requirement of the specific system.

Chlorinated biphenyls and chlorinated diphenyl oxides are not themselves suitable for use as the sole lubricant for refrigerant systems because of their poor viscosity-temperature relationships and high pour point. A viscosity of approximately 150 SUS at 100 F is generally preferred for the lubricant.

To better understand the nature and advantages of the present invention numerous comparative tests have been made directed to thermal stability and lubricity. A perusal of the following non-limiting examples illustrate the present invention.

With regard to thermal and chemical stability, the standard "sealed tube test" has been utilized. This test is described in detail by H. Elsey in "Small Sealed



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Tube Procedure for Quality Control of Refrigeration Oils", 71 ASHRAE Transactions, Pt. 1, p. 143 (1965). Generally, this test involves introducing equal amounts of oil and refrigerant and samples of the compressor metals employed with which the lubricant and refrigerant come in contact, into a clean, dry glass tube which is sealed and heated to 175°C and held for a long period of time. These tubes are visually inspected for changes in color and appearance of the metals and deposits. Table II is a table showing thermal aging properties of various oil base stocks, synthetic esthers and chlorinated biphenyls:

TABLE XI

Thermal Aging Tests (175°C) on Lube Oil Base Stocks
Rating - Days to Failure

| | OIL | R-12 (DAYS) | R-22 (DAYS) |
|---|---|---|---|
| 1 | Suniso® 3GS (Sun Oil Co.) | 28-54 | 453 |
| 2 | Texas Capella® B (Texaco Inc.) | 42-49 | 363 |
| 3 | Neopentyl diester | 28 | 239 |
| 4 | Trimethylol propane triester | 28 | 300 |
| 5 | Pentaerythritol tetra ester | 335 | 300 |
| 6 | Dipentaerythritol Ester | 90 | 49 |
| 7 | 42% chlorinated biphenyl | 383 | 458 |
| 8 | 48% chlorinated biphenyl | 383 | 453 |
| 9 | Super Refined Hydrocarbon Oil | 28 | 300 |
| 10 | Super Refined Mineral Oil (MLO 7557) | 339 | 453 |
| 11 | Hydrofined Naphthenic Oil (Tufflo® 6034) | 350 | 453+ |
| 12 | Hydrofined Naphthenic Oil (Tufflo® 6014) | 328 | 453+ |
| 13 | Hydrofined Naphthenic Oil (Tufflo® 6024) | 104 | 453+ |
| 14 | Hydrofined Paraffinic Oil** (Tufflo® 6016) | 364 | 453+ |
| 15 | Hydrofined Paraffinic Oil** (Tufflo® 6026) | 364 | 453+ |
| 16 | Suniso® 3GS + tricresylphosphate (1%) (anti-wear additive) | 8 | 8 |
| 17 | Suniso® 3GS + 1% Zinc dialkyldithiophosphate (anti-wear additive) | 8 | 8 |

** While these base stocks provide excellent thermal aging results, their pour point is generally considered too high.

Thus, Table II shows the resistance to thermal aging of both the chlorinated biphenyls and mineral oil base stocks in the presence of the R-12 and R-22 fluorocarbon refrigerant. Particular attention is directed to tests 16 and 17, wherein 1% of anti-wear additives to the oil of test 1, catastrophically degrades the thermal properties of the oil.

It was found that the composition comprising the halogenated aromatic in an oil lubricant continues to provide lubricity to the system even after the base oil has thermally aged.

Greatly improved wear properties are obtained with the lubricating compositions of the present invention. To demonstrate this, the lubricants were subjected to rigorous testing on the Falex Tester. See, "Falex Lubricant Testing Machine" Instructor Manual issued by Faville-Le Valley Corp., 1229 Bellwood Avenue, Bellwood, Illinois. Generally, the Falex wear test is made by applying a known load to two self-aligning V-blocks that squeeze a small rotating shaft. In testing, a new test piece is broken-in at about 50 pounds (gauge) for 10 minutes followed by a 200 pound (gauge) run for 5 minutes. A load of 250 pounds (gauge) is applied for the duration of the test which is approximately 4 hours. A 250 pound (gauge) corresponds to about 15,000 - 20,000 psi on the projected wear area and represents a very severe test for boundary lubricating ability. Any wear which occurs on the test pieces is reflected by a drop in the applied load as indicated on the gauge. Thus, every fifteen minutes the gauge is readjusted to 250 pounds and the take-up is recorded on a calibrated wheel as wear units. The wear in the following table is expressed as "wear units per hour" and represents the total number of units recorded over a four hour period divided by

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four. For practical purposes, wear rates of from 0 to 6 per hour are essentially equivalent because the wear is so little that it is difficult to measure, and differences are often due to errors in measurement.

Table III is illustrative of the present invention utilizing mineral oils, such as Tufflo® series 6004 and 6014,

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and a polybutene such as Syntholube® H-5 with the indicated halogenated aromatics in the designated amounts:

TABLE III

Falex Wear Tests on Refined Oils Plus Lubricity Additives (250 lb. ga. load, 4 hr. test)

| LUBRICANT COMPOSITION | DURATION | WEAR (UNITS/HR |
|---|---|---|
| 1 Tufflo® 6004 | Failed in 30 sec. | |
| 2 Tufflo® 6004 + 1% of 42%-chlorinated biphenyl | 17 minutes, failed | |
| 3 Tufflo® 6004 + 2.5% of 42%- chlorinated biphenyl | 240 minutes | 48.5/hr. |
| 4 Tufflo® 6004 + 5% of 42%-chlorinated biphenyl | 240 minutes | 60.0/hr. |
| 5 Tufflo® 6004 + 7.5% of 42% -chlorinated biphenyl | 240 minutes | 34.0/hr. |
| 6 Tufflo® 6004 + 10% of 42%-chlorinated biphenyl | 240 minutes | 28.5/hr. |
| 7 Tufflo® 6004 + R-22 | 240 minutes | 0/hr. |
| 8 Tufflo® 6004 + R-22 + 10% of 42%-chlorinated biphenyl | 240 minutes | 1.0/hr. |
| 9 Tufflo® 6014 | Failed on break in | |
| 10 Tufflo® 6014 + R-22 | 240 minutes | 0/hr. |
| 11 Tufflo® 6014 + R-22 + 10% of 42%-chlorinated biphenyl | 240 minutes | 0.75/ hr. |
| 12 Tufflo® 6014 + 10% of 42%-chlorinated biphenyl | 240 minutes | 16.25/hr. |
| 13 Syntholube® H-5 | Failed in 7 minutes | |
| 14 Syntholube® H-5 + 10% of 42%-chlorinated biphenyl | 240 minutes | 23.25/hr. |
| 15 Tufflo® 6014 + 2.5% Dodecylmonochloro DPO* | Failed 1 minute | |
| 16 Tufflo® 6014 + 5.0% Dodcylmonochloro DPO* | 240 minutes | 24/hr. |
| 17 Tufflo® 6014 + 7.5% Dodecylmonochloro DPO | 240 minutes | 21.75/hr. |
| 18 Tufflo® 6014 + 10% Dodecylmonochloro DPO | 240 minutes | 21/hr. |

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| | LUBRICANT COMPOSITION | DURATION | WEAR (UNITS/HR.) |
|---|---|---|---|
| 19 | Tufflo® 6014 + 10% trichlorobiphenyl + R-22 | 240 minutes | 0/hr. |
| 20 | Tufflo® 6014 + 10% trichlorobiphenyl | 240 minutes | 29.5/hr.** |
| 21 | Tufflo® 6014 + 10% Monochloro DPO | 240 minutes | 30.5/hr. |
| 22 | Tufflo® 6014 + 10% Dichloro DPO | 240 minutes | 22./hr. |
| 23 | Tufflo® 6014 + 10% trichlorobiphenyl | 240 minutes | 25/hr. |
| 24 | Tufflo® 6014 + 25% trichlorobiphenyl | 240 minutes | 6/hr. |
| 25 | Tufflo® 6014 + 50% trichlorobiphenyl | 240 minutes | 7.5/hr. |
| 26 | Tufflo® 6004 + 10% 2-Chlorobenzotri-fluoride | 165 minutes | Pin Broke |

* DPO indicates diphenyl oxide. ** 400 lb. gs. load.

Alternatively, Table IV illustrates the greatly improved wear resistance of commercially available refrigerator oils when modified as set forth herein. In this case, the tests were made using a premium brand refrigerator oil, Suniso® 3GS, and certain halogenated aromatics or other wear additives. As a comparison, the tests also included a premium grade motor oil and an automotive hypoid gear oil neither of which can be used in refrigerant systems. The table shows that lubricating composition of the present invention exhibits extremely good lubricating quality comparable to highest quality non-refrigerant oils.

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TABLE IV

Falex Tests on Selected Oils
(250 # gk. load, 4 hr. test)

| | LUBRICANT COMPOSITION | DURATION (240 min) | WEAR (UNITS/HR) |
|---|---|---|---|
| 1 | Suniso® 3GS | 74 min. | Failed - Broke Shear Pin |
| 2 | Suniso® 3GS + 10% of 42%-chlorinated biphenyl | 240 min. | 30.4/hr. |
| 3 | Suniso® 3GS + 10% of 48%-chlorinated biphenyl | 240 min. | 21.5/hr. |
| 4 | Suniso® 3GS + R-22 | 240 min. | 3.5/hr. |
| 5 | Suniso® 3GS + R-12 | 240 min. | 0/hr. |
| 6 | Suniso® 3GS + 10% Aroclor® 1242 & R-22 | 240 min. | 0/hr. |
| 7 | Suniso® 3GS + 1.5% Tricresyl phosphate | 240 min. | 2/hr. |
| 8 | GE Compressor Oil WS 98X-223 | 240 min. | 2.5/hr. |
| 9 | Suniso® 3GS + 10% 4-Chlorobenzotrifluoride | 240 min. | 1.75/hr. |
| 10 | Suniso® 3GS + 10% 2-chlorobenzotrifluoride | 240 min. | 1/hr. |
| 11 | Suniso® 3GS + 10% benzotrifluoride | 240 min. | 6.25/hr. |
| 12 | Suniso® 3GS + R-12 | 240 min. | 0/hr. |
| 13 | Suniso® 3GS + 10% of trichlorobiphenyl + R-22 | 240 min. | 1/hr. |
| 14 | Suniso® 3GS + 50% of trichlorobiphenyl | 240 min. | 13.25/hr. |

| | LUBRICANT COMPOSITION | DURATION (240 min) | WEAR (UNITS/HR) |
|---|---|---|---|
| 15 | Suniso® 5GS + 1% Lubrizol 1097* | 240 min. | 14.8/hr. |
| 16 | Suniso® 3GS + 1% Lubrizol 1395* | 240 min. | 4.9/hr. |
| 17 | Gulfpride® Single G Motor Oil | 240 min. | 0/hr. |
| 18 | Esso GX90 Hypoid Gear Oil | 240 min. | 3.5/hr. |

* The Lubrizols are zinc dithio compounds used as anti-wear additives.

These tests show the outstanding boundary lubricating properties of the present invention utilizing as a component a high grade refrigerant. It was also found, as mentioned above, and as quantitatively shown in Tables III and IV, that R-22 and R-12 impart improved lubricity to the oil. Both of these refrigerants, functioning as "fleeting" additives, have a beneficial effect in improving the lubricating quality of both premium refrigerator oils and also mineral oil base stock with or without additives.

As stated above, the present invention provides lubricating composition which overcomes the problem associated with cold start-up. The following test illustrates this feature.

The cold start simulating test stand consists of a compressor and motor to drive it, a condenser, a by-pass valve which recirculates the hot gas from the compressor discharge back to the compressor suction at a pressure of approximately 20 to 25 psi and an expansion

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valve feeding directly into the suction line from the condenser. By adjustment of the expansion valve, a mixture of liquid and vapor is achieved and the suction line and compressor are effectively converted into an evaporator thereby making this portion of the system the coldest portion. When the compressor is stopped a substantial portion of the refrigerant migrates to this cold portion of the system and assumes the liquid state. Upon restarting, loss of oil pressure, as previously described, occurs. By cycling the cold start simulating test stand, four minutes with the compressor running and four minutes with the compressor stopped, an excellent test is created for evaluating a lubricant's ability to prevent wear in boundary or partial film lubrication under cold start condition.

Table V below shows the wear data obtained using the cold start simulating test with Suniso® 3GS, and with Suniso® 3GS + 10% of 42% chlorinated biphenyl (see Table IV examples #1 and #2). Of the two bearings referred to in the table the one closest to the oil pump outlet is Brg #4 and the one furthest from the oil pump outlet is Brg #1 respectively. The real improvement demonstrated by the use of 42% chlorinated biphenyl is shown by the wear in the bearing #1 furthest from the pump, since this bearing experiences greater oil starvation and this more closely simulates true boundary lubricating conditions.

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TABLE V

Bearing Wear Data

| Item | Oil | Duration | Brg #1 | Brg #4 |
|---|---|---|---|---|
| 1 | Suniso® 3GS | 3000 cycles | 0.00120" | 0.0002" |
| 2 | Suniso® 3GS + 10% of 42% chlorinated biphenyl | 3000 cycles | 0.00075" | 0.00018" |

The order of magnitude of improvement obtained by using 42% chlorinated biphenyl on the oil is a 40% reduction in wear.

Typical lubricating compositions of this invention were tested under actual operating conditions. This test utilized a standard compressor used on an ice cream delivery truck. This unit was continuously operated in a high temperature environment and was used as an endurance testing device. Both Suniso® 3GS and Suniso® 3GS + 10% of 42% chlorinated biphenyl were used as the lubricant with a standard refrigerant for this application comprising a mixture of 48.8% of R-22 and 51.2% of monochloropentafluoroethane in these tests. The results are tabulated in Table VI.

TABLE VI

| | Suniso® 3GS | Suniso® 3GS + 10% Chlorinated biphenyl |
|---|---|---|
| Duration | 1819.8 hrs. | 2668.0 hrs. |
| Piston & Sleeve | Slight Scoring | Excellent |
| Discharge Valve | Black Resinous Deposits (Approx. .010 thick) | Light to Dark Brown Deposits (Approx. .002 thick) |
| Bearings | Completely Failed. All overlay gone. | Approx. .0015 wear. Running normally. |
| Crankshaft | Badly scored and worn. Blue from excess heat. | Slight scratches. No significant wear. |

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An outstanding improvement attained by incorporating the halogenated aromatic in the lubricant is evidenced by the data in the Table.

While emphasis has been made on the use of lubricating compositions in refrigerators, it should be understood that heat pumps, which are basically refrigerators, and similar devices can advantageously employ the lubricant compositions of this invention.

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W.E. Case 42,874
Serial No. 138,395

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A compressor refrigerant system employing a fluorocarbon refrigerant combined with a lubricating composition in contact with the fluorocarbon, the lubricating composition comprising an oil having a viscosity of 100°F of from 100 to 300 SUS, and at least 1% by weight thereof of a liquid halogenated polyphenyl compound selected from halogenated biphenyls, diphenyl ethers and alkyl derivatives thereof, the halogen being at least one of chlorine and fluorine.

2. A system according to claim 1, wherein the liquid halogenated compound is an alkyl chlorodiphenyl oxide with an average of one chlorine group and one alkyl group per molecule.

3. A system according to claim 2, wherein the alkyl chlorodiphenyl oxide is dodecylmonochlorodiphenyl oxide.

4. A system according to claim 1, 2 or 3, wherein the oil is a highly refined mineral oil having substantially no sulphur-oxygen-or nitrogen-containing compounds, substantially no unsaturated hydrocarbons and a pour point not greater than -25°F.

5. A system according to any of claims 1, 2 or 3, wherein the liquid halogenated compound is present in an amount of up to 20% by weight of the oil.

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6. A system according to claim 1, 2 or 3, wherein the liquid halogenated compound is present in an amount of from 10 to 20% by weight of the oil.

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THERMALLY STABLE LUBRICANTS FOR REFRIGERATOR SYSTEMS

ABSTRACT OF THE DISCLOSURE

A chemically and thermally stable lubricating composition having high lubricity for use in fluorocarbon refrigerant systems comprising either hydrofined stock base oils or refrigerator oils and halogenated aromatics including chlorinated biphenyls, chlorinated polyphenyls, and chlorinated diphenyl ethers.